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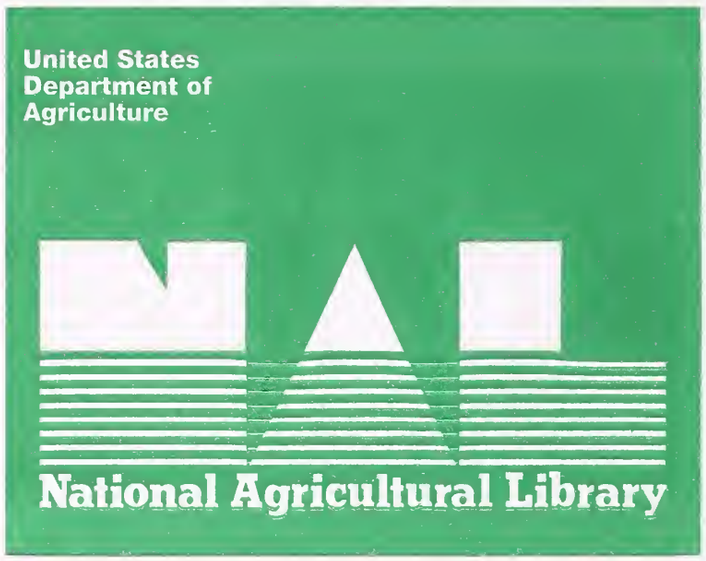
Nutrient Composition of Whole Vertebrate Prey (excluding fish) Fed in Zoos

May 2002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May 2002

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Disclaimers

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NUTRIENT COMPOSITION OF WHOLE VERTEBRATE PREY (EXCLUDING FISH) FED IN ZOOS

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Although nutritionally balanced formulations, largely based upon nutrient requirements of domestic cats, are commercially available for many zoo carnivores, some choose to use whole prey as a part or all of certain captive feeding programs. Whole prey are similar in physical form to the natural diet of some carnivores, and are commonly presumed to meet nutrient requirements as long as nearly all soft tissues and some bones (or other calcified tissues) are consumed. This use has the potential to positively influence behavior, and may have positive, indifferent, or negative effects on health. Prey sizes offered are commonly related to consumer body size. Prey species offered tend to relate to documented or perceived natural feeding habits and/or individual animal preferences. Little consideration has been given to differences in nutrient composition associated with prey species, age, sex, and diet.[7,14,15] Further, origin, handling, and storage methods influence the nutritional value and healthfulness of prey. These issues, as well compositional data, are discussed in the following sections.

Sources, Receipt, Handling, and Storage of Prey

Whole prey items, when used, often constitute the most expensive part of a carnivore diet. Thus, it is important that methods of procurement, receipt, handling, and storage preserve their nutritional value and maximize the benefits of their use.

Sources

A partial list of whole prey vendors is provided in Appendix 1 (inclusion does not necessarily imply endorsement). Additionally, local research facilities are sometimes willing to donate laboratory animals to zoos as food for carnivores.

Prey suppliers should house, manage, and ship their animals in conformity with the Animal Welfare Act (Public Law 89-544), first passed in 1966 and amended in 1970, 1976, 1985, 1990, and 2002 (see http://www.aphis.usda.gov/ac). Medical care of prey species should be appropriate to ensure that these animals will not be a source of parasites and infectious diseases.[16] If animals are killed before shipment, techniques recommended by the AVMA Panel on Euthanasia[3] to minimize pain and distress should be used. Of course, the euthanasia technique chosen must not leave a residue that may harm the prey consumer.

Standing orders for vertebrate prey (either live or frozen) help assure a constant supply since the supplier is able to regulate breeding schedules to meet anticipated demand. Live animals from vendors are commonly shipped via United Parcel Service (UPS), or other ground mail services, and upon occasion may be exposed to adverse environmental conditions. If animals are shipped frozen, potential problems parallel the shipment of other frozen items.

Inspection upon receipt

Upon receipt, a shipment should be examined visually for signs of damage or poor handling. Live animals should have been supplied with food and water and should appear comfortable, without evidence of overheating (such as panting or prostration) or excessive cold exposure (huddled in groups). If there is a problem related to package handling, this should be addressed with a representative of the transport company at the time of receipt. Persistent shipment problems should be discussed with the prey vendor so a different transport company may be chosen, if necessary.

Frozen shipments should not show evidence of thawing during transport (such as free moisture, ice crystals on the prey, appearance or odor of spoilage). Once frozen, prey should not be allowed to thaw until needed. While vacuum packaging prolongs the storage life of frozen meat and poultry for human consumption,[35] specific studies with frozen whole prey have not been conducted to determine whether this packaging would be beneficial for zoological institutions.

Periodic chemical evaluations of quality will help ensure that the prey animals have been properly nourished. As a minimum, whole prey should be analyzed for percent water (conversely, dry matter), crude protein, crude fat, and ash. Mineral and vitamin analyses can provide additional valuable information. Protocols for sampling and a discussion of appropriate analytical techniques are presented in NAG Fact Sheet 010 (Quality Control of Feedstuffs: Chemical Analysis).

When prey are purchased by number, the number of animals delivered should be counted. With the best of intentions, mistakes in types or amounts of product shipped can occur. A log documenting lot number, type of whole prey, quantity, and quality should be maintained. This log can help trace problems to particular vendors and can supply information on the quality of handling prior to receipt. When prey are ordered through a bid system, this documentation may be the minimum needed to remove an unacceptable vendor from the bid list.

Storage

Whole prey items that arrive frozen should be handled similarly to frozen meat and fish products. Upon receipt, all frozen items should be immediately placed in a freezer at an average product temperature of -18° to -30° C, or, if being thawed for feeding the following day, in a refrigerator at a temperature of 2° to 3.5° C. Note, however, that the feeding of frozen and/or partially frozen whole prey can provide improved gum stimulation, less potential for bacterial growth, tends to slow ingestion, and is less smelly. Regardless of whether fed thawed or frozen, all items should be well covered with moisture-impermeable

plastic to reduce dehydration during storage. Stock should be rotated so that the oldest items will be used first, thus ensuring that storage length times will be kept to a minimum.

Live animals that have been purchased for use as prey should be housed, fed, and euthanized in conformity with the Animal Welfare Act and the recommendations of the AVMA Panel on Euthanasia referred to as referenced above.

Related issues

Upon occasion, road-killed animals have been used as food for captive carnivores. This is a practice that is discouraged. Uncertainty concerning prior health status, and spoilage following death, make such a practice very risky. Sick animals or animals that have died of illness or unknown causes, of course, should not be used for carnivore food. Further, if muscle only is fed, it does not constitute a nutritionally complete diet, being particularly deficient in calcium. Proper diets for large felids in institutions subject to federal inspection are discussed to a limited extent in USDA/APHIS Policy #25 (http:// www.aphis.usda.gov/ac/policy/policy25).

Composition of Prey

Tables 1-3 summarize published data on nutrient composition of various species of whole vertebrate prey (excluding fish) fed in zoos. Additionally, unpublished information was requested from the international zoo community and is reported separately in Tables 4-6. Specific nutrients and nutrient interactions warranting further investigation are suggested. Values are expressed as weighted means, or raw means when *n* was not stated. Ranges, standard deviations, standard errors, or coefficients of variation are not given, although there may be considerable variation among individual values. Examination of the original reference(s) is encouraged.

Proximate fractions (Tables 1 and 4)

Water. Whole prey may comprise the primary or only source of water for many carnivores in nature. [Note: the AWA requirements include potable drinking water for regulated animals. Although the animal may chose not to drink, water should be provided separately at all times.] Species included in this summary contain 60 to 85% water, on an as-fed basis, with a modal range of 70 to 75%. As is typical for other studied species, water content decreases with age, while energy density increases.

Protein. Lean (protein) and fat, as fractions of whole body mass, are inversely related. Overall, whole prey fed to captive carnivores provide crude protein in excess of the estimated requirements of domestic carnivores. Protein and essential amino acid requirements of zoo carnivores have not been determined, and reports on the amino acid composition of whole prey are very limited.[25] Given the high concentration of protein in prey, and the lack of reports of overt amino acid deficiencies, it is probable that amino acid requirements will be met.

Fat. The crude fat content of most whole prey is much higher than the recommended minimum dietary levels (approximately 5 to 10% of dietary dry matter (DM)) for domestic carnivores.[22,23] Neonates have lower body fat concentrations than do older prey animals, and skinned, eviscerated carcasses contain lower fat concentrations than do the whole bodies of prey animals of the same age. Amphibians, in general, contain lower body fat concentrations than do mammals or birds. Most laboratory-reared rodents contain more body fat and less body protein than sampled free-ranging rodents of the same species,[6] perhaps due to energy-dense captive diets and limited exercise.

Although prey body fat is a source of readily available energy for zoo carnivores, essential fatty acid requirements appear not to have been determined. Minimum dietary requirements of domestic cats for linoleic and arachidonic acids have been set at 0.5 and 0.2% of DM, respectively.[23] Requirements for ω-3 fatty acids, such as α-linolenic or longer-chain fatty acids, have not been defined. Assuming that zoo carnivores have fatty acid requirements similar to those of the domestic cat, the few studies in which fatty acid composition of whole prey has been reported[9,11,23] suggest that essential fatty acid supplies would be adequate. However, peroxidation during extended or improper storage of prey may result in declines in essential fatty acid activity and destruction of vitamin E.[9]

Ash. Mineral concentrations in whole prey vary considerably, depending upon prey type and, to some extent, age. Neonates often, but not always, contain a lower proportion of total ash compared with adults. Data for some samples are reported as a fraction of "dressed carcass", with head, skin, and viscera removed and with bones remaining. Hence, ash concentration is a higher fraction of carcass dry matter than of the intact body. Specific mineral concentrations in relation to the dietary requirements of carnivores are discussed below.

Fat-soluble vitamins (Tables 2 and 5)

Vitamin A. Vitamin A concentrations tend to increase with age/maturity in vertebrate prey through accumulation in body stores.[7,15] The liver is the major vitamin A storage organ for those species that have been studied, and liver vitamin A concentrations vary with carotenoid and vitamin A intake. Thus, body vitamin A stores also would be expected to vary with levels of carotenoids and vitamin A in the diets of prey. Adult laboratory-reared rodents, such as rats and mice, appear to contain higher levels of vitamin A than do free-ranging rodents, such as prairie dogs. Species differences in vitamin A concentration are apparent even within broad taxonomic categories, but all whole prey analyzed to date would appear to exceed the dietary requirements of domestic dogs[22] and cats[23] (approximately 4,000 IU/kg DM) without a need for further supplementation. In fact, some of the concentrations reported approach or exceed presumed upper safe limits for this nutrient (33,000 IU/kg DM for dogs to 100,000 IU/kg DM for cats).[24]

Vitamin E. Vitamin E concentrations in the whole prey species that have been analyzed meet the estimated requirements of dogs[22] and cats[23] (about 30 IU/kg DM) when fed diets with moderate levels of polyunsaturated fatty acids (PUFAs). High dietary levels of PUFAs may increase the vitamin E requirement fivefold. Vitamin E deficiency, adversely impacting reproduction and health, has been documented in raptors fed whole quail. It was necessary to feed the prey quail approximately 200 IU vitamin E per kg dietary DM to

provide adequate levels of this nutrient to the secondary consumer.[12] Clear species differences in vitamin E metabolism/utilization have been shown between laboratory mice and rats raised on the same diets,[7,15] suggesting that species that have not been studied may have different requirements. In addition, vitamin E requirements for optimum function of the immune system appear to be higher than levels needed to prevent the usual signs of deficiency, at least in rats and humans.[5;20]

Minerals (Tables 3 and 6)

Macrominerals. Macromineral requirements (as a percentage of dietary DM) for growing mammal and bird species (Ca, 0.4 to 1.2%; K, 0.2 to 1.4%; Mg, 0.03 to 0.1%; P, 0.3 to 0.6%; and Na, 0.05 to 0.4%) appear to be met by any of the whole prey in this report. Calcium requirements for maximal egg production of indeterminate layers (no seasonality nor fixed limit to egg production) such as leghorn chickens (2.25 to 2.75% of dietary DM)[25] would be met by consumption of adult rodents, birds, reptiles, and amphibians, and it is probable that the Ca requirements of determinate layers (limited egg production) such as large raptors are lower.[29]

Trace minerals. Much variability among and within prey species in trace element composition is apparent. There are several possible reasons for this, including the influence of differing dietary trace mineral levels, species specific metabolism, varying accuracy of analytical techniques, and contamination of analytical samples. Mean copper concentrations range from about 2 to over 100 mg/kg of DM. Dietary requirements for copper (DM basis) are estimated to be 2.9 mg/kg for dogs,[22] 5 mg/kg for cats,[23] 8 mg/kg for chickens,[25] and 3-6 mg/kg for swine.[26] Considering the high bioavailability of copper in unprocessed animal tissues,[2] it is likely that requirements would be met by all prey items. However, it may be prudent to exercise caution in exclusive use of some high-copper prey as food for carnivores.

Iron requirements of the above species (32 to 110 mg/kg dietary DM) would probably be met by all prey, although some whole prey may contain inappropriately high levels of iron for individuals with a tendency to develop iron-storage disease.[29]

Recommended dietary levels of bioavailable zinc (10 to 50 mg/kg DM) would be met by most whole prey and are higher in free-ranging rodents compared with laboratory-reared mice and rats.[14]

Estimated manganese needs of dogs[22] and cats[23] (5 mg/kg dietary DM) would probably be met by most whole prey. The issue of bioavailability[2] is relevant here, and poor availability of manganese in some plant products is responsible for the elevated requirement of this nutrient in natural-ingredient chicken diets (up to 66 mg/kg DM).[25] Manganese requirements of chicks fed a semipurified dextrose-casein diet was estimated to be about 15 mg/kg DM.[32] The manganese requirements of carnivorous birds have not been determined, but evidence of manganese deficiency in raptors consuming whole prey in the wild has not been reported.

Data Gaps

Information on concentrations of fatty acids, vitamins D and K, the water-soluble vitamins, and essential amino acids in whole prey is lacking. The data that are available suggest that larger, physiologically more mature prey may constitute a very different diet for prey consumers, in terms of nutrient content, than smaller specimens of the same species. Likewise, different species of the same class of prey items may differ considerably in chemical and nutrient content, with much of this difference determined by the diet consumed. Diets fed to prey species that are intended as food for carnivores should be carefully assessed with respect to nutrient content, interactions, and persistence in tissues. In particular, the concentrations of fatty acids, fat- and water-soluble vitamins, and trace elements in diets fed to prey, and their effect upon prey composition, require further investigation. Such information should be considered integral to the development of optimal diets for whole prey used as food for other species, and all should be considered when assessing the adequacy of carnivore diets. Based upon current body composition data, additional macromineral and/or vitamin A supplementation of whole prey-based diets appears unwarranted.

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The authors wish to thank Kathryn Carroll (Katie) of the Manhattan College/College of Mount Saint Vincent, Riverdale, NY, for editorial assistance, and numerous students and colleagues for contributing to the data contained in this report. Review comments from CT Robbins and other colleagues of the American Zoo and Aquarium Association's Nutrition Advisory Group (NAG) improved earlier drafts of this document, as did the final review of BA Kohn of USDA - APHIS – Animal Care.

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Table 1. Proximate composition and energy content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated.

Prey species	*n*	DM %	Crude protein %	Crude fat %	Ash %	Gross energy kcal/g	Notes	References
MAMMALS								
Calf, Holstein	72	22.5	60.0	8.9	16.0	4.08	Fetal age, 190-270 days	4
Deer, white-tailed		22.3	80.7	6.3	17.9	4.62	Neonatal	29
Deer, white-tailed	22	36.9	57.0	24.5	13.8	5.63	Juvenile, ingesta-free	19, 39
Deer, white-tailed	6	41.1	47.4	41.4	11.4	6.34	Adults, ingesta-free	28
Guinea pig		29.1	51.2	34.7	14.1	5.95	Neonatal males	7
Guinea pig	6	31.3	51.4	46.1	9.2	6.99[a]	Males, 10 week	7
Hamster	6	30.3	49.8	34.7	7.5	5.98	Juvenile	34
Hare, snowshoe		28.0	73.0	2.9	17.5	4.66		28
Mink		18.0	72.8	11.7	10.0	5.39	Neonatal	27
Mouse, domestic	287	19.1	64.2	17.0	9.7	4.87[a]	Neonatal, <3 g	9, 13, 15
Mouse, domestic	292	18.2	44.2	30.1	8.5	6.65[a]	Juvenile, 3-10 g	9, 13, 15
Mouse, domestic	108	32.7	55.8	23.6	11.8	5.25[a]	Adult or >10 g	6, 7, 9, 13, 15
Mouse, jumping		29.7	62.9	18.7	12.9	5.50		28
Mouse, old-field	44	17.4	70.3	8.6	11.3	4.60[a]	Neonatal	15
Mouse, old-field	171	29.8	54.6	21.9	10.7	5.29[a]	Juvenile	15
Mouse, white-footed		34.1	59.7	19.9	12.9	5.51		28
Pig, domestic	32	28.9	50.7	33.2	11.9	5.78	Juvenile	31
Rabbit, black-tailed jack	3	27.0	74.4	4.5	15.0	4.54	Dressed carcass	28
Rabbit, domestic		15.4	72.1	13.0	14.9	5.06	Neonatal	27
Rabbit, domestic	2	26.2	65.2	15.8	3.4	5.30	Dressed carcass	27
Rat	5	20.8	57.9	23.7	12.2	5.30[a]	Neonatal, <10 g	15
Rat	5	30.0	56.1	27.5	14.8	5.55[a]	Juvenile, 10-50 g	15
Rat	51	33.9	61.8	32.6	9.8	6.37[a]	Adult or >50 g	6, 7, 15

Table 1 continued. Proximate composition and energy content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when "*n*" was not stated.

Prey species	*n*	DM %	Crude protein %	Crude fat %	Ash %	Gross energy kcal/g	Notes	References
Squirrel, fox		17.6	55.7	NA[b]	NA	4.89	Neonatal	28
Squirrel, gray		33.3	62.4	18.4	11.6	5.54		27
Vole, bank		15.5	63.2	24.5	10.3	5.68	Neonatal	28
Vole, common		16.5	64.2	16.4	12.7	4.97	Neonatal	28
Vole, meadow & red-backed		32.0	62.5	15.5	13.5	5.34		27
BIRDS								
Chicken	66	25.6	64.9	22.4	6.4	5.80	One-day-old	6, 34
Chicken	16	32.5	42.3	37.8	9.4	5.90[a]	Adult	6, 13
Duck, mallard	3	33.1	63.1	26.4	9.5	5.92	Dressed carcass	33
Quail, Japanese	18	34.6	71.5	31.9	9.9[c]	6.79[a]		7
REPTILES & AMPHIBIANS								
Frog, Cuban tree	19	26.6	NA	4.8	NA			1
Frog, green	7	22.5	71.2	10.2	NA	4.80[a]		30
Gecko, fox	5	25.3	NA	NA	NA			1
Lizard	151	28.8	NA	NA	15.9	5.50[d]	Nineteen species	38
Lizard, anolis	13	29.4	67.4	NA	NA	NA	Adult	8
Lizard, bearded dragon	17	17.9	63.6	NA	NA	NA	Various ages	8
Snake	4	28.0	NA	NA	17.0	6.51[d]	Four species	38
Toad, southern	1	26.4	61.8	13.7	NA	4.61[a]	Juvenile	30
Toad, southern	4	28.2	61.0	14.0	NA	4.25[a]	Adult	30

Dressed carcass = eviscerated whole body with head, feet, and skin removed.

[a]Calculated by adding the product of % crude protein x 5.43 kcal/g to the product of % crude fat x 9.11 kcal/g.[29]

[b]Not analyzed.

[c]Fat-free basis.

[d]Ash-free basis.

Table 2. Vitamin A and E content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated.

Prey species	*n*	Vitamin A IU/kg	Vitamin E IU/kg	Notes	References
MAMMALS					
Guinea pig	6	16,506	24.2	Males, 10 week	7
Mouse, domestic	6	35,533	52.7	Neonatal, <3 g	15
Mouse, domestic	17	30,888	173.9	Juvenile, 3-10 g	15
Mouse, domestic	24	578,272	100.4	Adult or >10 g	7, 15
Prairie dog, black-tailed		30,830	82.6	Mean of range	27
Prairie dog, white-tailed		16,000	88.5	Mean of range	27
Rabbit, domestic	2	6,200	NA[a]		27
Rat	5	21,333	470.4	Neonatal, <10 g	15
Rat	24	151,389	139.2	Adult or >50g	7, 15
BIRDS					
Chicken	6	35,600	51.3	Males	13
Quail, Japanese	18	70,294	66.8	Diet effects	7
REPTILES & AMPHIBIANS					
Frog, green	7	25,110	82.2		30
Lizard, anolis	19	4,880	44.8	Adult	8
Lizard, bearded dragon	15	38,562	95.5	Various ages	8
Toad, southern	1	15,940	231.8	Juvenile	30
Toad, southern	4	38,261	369.0	Adult	30

[a]Not analyzed.

Table 3. Mineral content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated.

Prey species	*n*	Ca %	P %	Mg %	Na %	K %	Cu mg/kg	Fe mg/kg	Zn mg/kg	Mn mg/kg	Notes	References
MAMMALS												
Calf, Holstein[a]	72	4.12	2.88	0.12	0.97	0.86	1.8	37.8	16.3	0.3	Fetal age 190-270 days	17
Deer, white-tailed	6	4.82	2.49	0.12	0.20	0.54	5.0	81.1	65.6	NA[b]	Juvenile, ingesta-free	19
Deer, white-tailed		3.09	2.26	0.19	0.39	0.95	26.1	164.5	68.4	28.5	Adult, ingesta-free	40
Guinea pig	6	3.02	NA	0.07	NA	NA	5.6	56.4	46.4	6.6	Males, 10 week	7
Hamster	6	2.51	2.03	0.12	0.46	0.88	12.0	237.0	94.0	45.0	Juvenile	34
Mouse, cotton		4.05	1.67	0.12	0.24	NA	NA	200.0	98.0	NA		29
Mouse, domestic	5	1.17	NA	0.11	NA	NA	19.2	181.3	82.5	0.2	Neonatal, <3 g	14
Mouse, domestic	5	1.47	NA	0.09	NA	NA	13.4	153.6	75.4	13.1	Juvenile, 3-10 g	14
Mouse, domestic	78	2.98	1.72	0.16	NA	NA	6.7	137.9	67.5	7.7	Adult or >10 g	6,7,13,14
Mouse, golden		3.74	1.92	0.14	0.36	NA	NA	240.0	110.0	NA		29
Mouse, old-field		1.60	1.86	0.06	0.43	1.20	NA	208.5	125.0	10.6	Mean of range	29
Prairie dog, black-tailed		1.54	1.14	0.07	0.26	0.47	5.0	215.0	75.0	3.5		27
Rabbit, domestic	2	5.93	3.43	0.18	0.26	0.72	4.6	100.0	84.0	2.4		27
Rat	5	1.85	NA	0.14	NA	NA	60.6	275.8	113.6	6.2	Neonatal, <10 g	14
Rat	10	2.07	NA	0.12	NA	NA	11.3	133.2	81.9	2.6	Juvenile, 10-50 g	14
Rat	49	2.62	1.48	0.08	NA	NA	6.3	148.0	62.1	11.0	Adult or >50 g	6, 7, 14
Shrew, short-tail		3.44	1.72	0.14	0.42	NA	NA	500.0	120.0	NA		29
Squirrel, fox		2.56	1.30	0.13	0.84	1.07	NA	NA	NA	NA	Mean of range	29
BIRDS												
Chicken	66	1.69	1.22	0.05	0.71	0.80	5.2	119.5	97.4	3.9	One-day-old	6, 34
Chicken	16	2.22	1.40	0.50	NA	NA	3.6	122.2	116.1	10.1	Adult	6, 13
Goldcrest		2.84	1.88	0.11	0.40	0.58	NA	NA	NA	NA		29

Table 3 continued. Mineral content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when "*n*" was not stated.

Prey species	*n*	Ca %	P %	Mg %	Na %	K %	Cu mg/kg	Fe mg/kg	Zn mg/kg	Mn mg/kg	Notes	References
Pipit, meadow		2.04	1.65	0.13	0.83	1.28	NA	400.0	107.0	13.5	Mean of range	29
Quail, Japanese	18	3.43	NA	0.06	NA	NA	2.6	74.9	53.0	6.4		7
Rook		2.04	1.75	0.09	0.45	0.94	11.0	475.0	96.5	31.0	Mean of range	29
Tit, blue		3.28	2.04	0.10	0.37	0.58	NA	NA	NA	NA		29
Tit, coal		3.31	2.08	0.11	0.39	0.63	NA	NA	NA	NA		29
REPTILES & AMPHIBIANS												
Frog, Cuban tree	19	4.79	2.57	NA	NA	NA	NA	NA	NA	NA		1
Frog, green	7	4.29	1.87	2.47	0.55	NA	11.2	102.6	100.3	11.5		30
Gecko, fox	5	5.22	2.18	NA	NA	NA	NA	NA	NA	NA		1
Lizard, anolis	13	5.54	2.88	0.15	0.33	0.73	5.0	127.8	142.5	4.0	Adult	8
Lizard, bearded dragon	18	3.53	2.35	0.16	0.66	1.12	8.9	276.4	133.3	9.3	Various ages	8
Tadpole, bullfrog		2.60	NA	0.68	NA	0.18	3.3	NA	19.3	59.0		10
Toad, southern	1	5.16	2.68	0.07	0.36	NA	127.0	294.7	471.6	11.1	Juvenile	30
Toad, southern	4	2.94	1.79	0.06	0.36	NA	117.4	286.0	662.9	4.7	Adult	30

[a]All mineral values for this prey species were calculated from equation given in reference.
[b]Not analyzed.
Key to minerals:

Ca - calcium	Na - sodium	Fe - iron
P - phosphorus	K - potassium	Zn - zinc
Mg - magnesium	Cu - copper	Mn - manganese

Table 4. Proximate composition and energy content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated. Unpublished data submitted in 1999.

Prey species	*n*	DM %	Crude protein %	Crude fat %	Ash %	Gross energy kcal/g	Notes	References
MAMMALS								
Hamster	2	32.0	51.2	26.0	7.2	5.14[a]		WCS
Mouse, domestic	30	26.1	50.8	34.4	8.0	6.23	Neonatal, <3 g	CZS, DZ
Mouse, domestic	57	28.7	59.2	23.8	10.0	5.84	Juvenile, 3-10g	DZ, LAZ
Mouse, domestic	7	32.6	56.9	23.5	11.3	5.77	Adult or >10 g	CZS, DZ
Rabbit, domestic	1	28.1	63.5	15.3	9.4	5.41		MTZ
Rabbit, domestic	1	33.5	71.2	14.6	11.1	5.22	Eviscerated, incl. hide	MTZ
Rabbit, domestic	2	31.3	63.2	20.0	16.0	5.25[a]	Eviscerated, incl. hide	WCS
Rabbit, domestic	6	28.4	61.8	22.6	12.8	5.42[a]	Meat incl. heart, lungs, kidneys	WCS
Rat	22	31.1	60.4	35.0	10.9	5.67		LAZ, MTZ
Rat	15	23.0	60.3	26.8	11.8	5.67[a]	Juvenile, 10-50 g	WCS
BIRDS								
Chicken	11	22.8	67.7	16.5	8.2	5.82	Juvenile	LAZ, DZ
Chicken	1	40.5	45.0	51.1	6.2	6.58	Adult	MTZ
REPTILES & AMPHIBIANS								
Lizard, anolis	4	27.2	66.0	9.0	15.2	4.80		CZS, WCS
Tadpole, bullfrong	1	12.4	NA	16.4	44.0	NA[b]	Young	WCS
Tadpole, bullfrog	1	17.6	34.4	31.4	19.9	4.73[a]	Mature	WCS
Tadpole	3	6.9	23.3	21.3	22.7	4.59	Puerto Rican crested toad	MTZ

[a]Calculated by adding the product of % crude protein x 5.43 kcal/g to the product of % crude fat x 9.11 kcal/g.[29]
[b]Not analyzed.
Key to references:
CZS - Chicago Zoological Society
DZ - Detroit Zoo
LAZ - Los Angeles Zoo
MTZ - Metro Toronto Zoo
WCS - Wildlife Conservation Society

Table 5. Vitamin A and E content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated. Unpublished data submitted in 1999.

Prey species	*n*	Vitamin A IU/kg	Vitamin E IU/kg	Notes	References
MAMMALS					
Hamster	2	26,666	12.4		WCS
Mouse, domestic	5	17,000	7.0	Neonatal, <3 g	CZS
Mouse, domestic	1	130,000	6.0	Adult or >10g	CZS
Rabbit, domestic	2	NA[a]	60.0	Eviscerated carcass	WCS
Rabbit, domestic	6	NA	16.2	Meat incl. heart, lungs, kidneys	WCS
Rat	15	19,265	139.4	Juvenile, 10-50 g	WCS
REPTILES AND AMPHIBIANS					
Lizard, anolis	4	10,583	11.9		WCS
Tadpole, bullfrog	1	NA	21.6	Young	WCS
Tadpole, bullfrog	1	NA	18.0	Mature	WCS
Tadpole	3	8,727	62.3	Puerto Rican crested toad	MTZ

[a]Not analyzed.

Key to references:

CZS - Chicago Zoological Society
MTZ - Metro Toronto Zoo
WCS - Wildlife Conservation Society

Table 6. Mineral content of whole prey on a dry matter (DM) basis. Values expressed as weighted means or as raw data when sample size "*n*" was not stated. Unpublished data submitted in 1999.

Prey species	*n*	Ca %	P %	Mg %	Na %	K %	Cu mg/kg	Fe mg/kg	Zn mg/kg	Mn mg/kg	Notes	References
MAMMALS												
Mouse, domestic	30	3.54	1.63	0.12	0.51	1.15	11.0	158.7	77.0	3.6	Neonatal, <3 g	CZS, DZ
Mouse, domestic	57	2.96	1.84	0.12	0.49	1.03	12.1	311.9	96.5	9.5	Juvenile, 3-10 g	DZ, LAZ
Mouse, domestic	7	2.64	1.91	0.13	0.43	1.02	8.0	251.0	89.4	11.5	Adult or >10g	CZS, DZ
Rabbit, domestic	1	2.35	1.68	0.16	0.54	0.94	16.0	302.0	86.0	16.9		MTZ
Rabbit, domestic	1	1.85	1.36	0.12	0.44	0.87	3.0	100.0	76.0	3.0	Eviscerated	MTZ
Rabbit, domestic	3	2.25	1.72	0.19	NA[a]	NA	22.2	127.0	73.0	2.4	Eviscerated	WCS
Rabbit, domestic	2	0.64	0.53	0.15	NA	NA	41.0	90.4	55.4	1.2	Whole, incl. GIT	WCS
Rat	22	3.45	1.91	0.15	0.43	1.05	7.5	194.9	92.1	15.3		LAZ, MTZ
BIRDS												
Chicken	11	1.73	1.21	0.08	0.82	0.81	4.0	157.4	93.9	3.3	Juvenile	MSU
Chicken	1	1.68	1.30	0.09	0.26	0.53	3.0	40.0	45.0	3.0	Adult	MSU
REPTILES & AMPHIBIANS												
Lizard, anolis	3	2.30	2.60	0.14	0.50	1.00	353.0	134.0	315.0	3.0		CZS
Tadpole	3	7.67	1.67	0.15	0.73	0.88	46.7	610.2	278.8	58.4	Puerto Rican crested toad	MTZ

[a]Not analyzed.

Key to references:

CZS - Chicago Zoological Society
DZ - Detroit Zoo
LAZ - Los Angeles Zoo
MSU - Michigan State University
MTZ - Metro Toronto Zoo
WCS - Wildlife Conservation Society

Table 7. Scientific names of whole prey species.

Common name	*Genus species*
MAMMALS	
Calf, Holstein	*Bos taurus*
Deer, white-tailed	*Odocoileus virginianus*
Guinea pig	*Cavia porcellus*
Hamster	*Mesocricetus auratus*
Hare, snowshoe	*Lepus americanus*
Mouse, domestic	*Mus domesticus*
Mouse, jumping	*Napaeozapus insignis*
Mouse, old-field	*Peromyscus polionotus*
Mouse, white-footed	*Peromyscus leucopus*
Muskrat	*Ondatra zibethicus*
Prairie dog, black-tailed	*Cynomys ludovicianus*
Prairie dog, white-tailed	*Cynomys leucurus*
Rabbit, black-tailed jack	*Lepus californicus*
Rabbit, domestic	*Oryctolagus cuniculus*
Rat	*Rattus norvegicus*
Shrew, short-tail	*Blarina brevicauda*
Squirrel, fox	*Sciurus niger*
Squirrel, gray	*Sciurus carolinensis*
Vole, bank	*Clethrionomys glareolus*
Vole, common	*Microtus arralis*
Vole, meadow	*Microtus pennsylvanicus*
Vole, red-backed	*Clethrionomys gapperi*
BIRDS	
Chicken	*Gallus gallus*
Duck, mallard	*Anas platyrhynchos*
Goldcrest	*Regulus regulus*
Pipit, meadow	*Anthus pratensis*
Rook	*Corvus frugilegus*
Quail, Japanese	*Coturnix coturnix*
Tit	*Parus* spp.
REPTILES & AMPHIBIANS	
Frog, Cuban tree	*Osteopilus septentrionalis*
Frog, green	*Rana clamitans*
Gecko, fox	*Hemidactylus garnoti*

Table 7 continued. Scientific names of whole prey species.

Common name	*Genus species*
Lizard (19 spp.)	*Coleonyx variegatus*
	Callisaurus draconoides
	Cophosaurus texanus
	Crotaphytus collaris
	Gambelia wislizeni
	Holbrookia maculata
	Phrynosoma cornutum
	Phrynosoma modestum
	Phrynosoma platyrhinos
	Sceloporus clarki
	Sceloporus magister
	Sceloporus scalaris
	Sceloparus undulatus
	Sceloporus virgatus
	Urosaurus graciosus
	Urosaurus ornatus
	Uta stansburiana
	Cnemidophorus tigris
	Xantusia vigilis
Lizard, anolis	*Anolis carolinensis*
Lizard, bearded dragon	*Pogona vitteceps*
Snake (4 spp.)	*Chilomeniscus cinctus*
	Contia tenuis
	Salvadora hexalepus
	Sonora semiannulata
Tadpole, bullfrog	*Rana catesbeinana*
Tadpole, Puerto Rican crested toad	*Peltophryne lemur*
Toad, southern	*Bufo terrestris*

Appendix 1. Partial listing of whole vertebrate prey commercial suppliers (USA).

Name	Address	City	State	Zip	Telephone	Fax	Website/email
Bayou Rodents	9008 Highway 182 W., P.O.Box 238	Centerville	LA	70522	800-722-6102	337-836-5346	bayourodents@cox-internet.com
BGC Exotic Pet Foods	7715 Robe Menzel Road	Granite Falls	WA	98252	877-691-3599	360-691-6510	www.bgcpetfoods.com "baby chicks only, no rodents"
Big Cheese Rodents	Rt. 1 Box 59A	Iredell	TX	76649	800-887-0921	254-364-2874	www.bigcheeserodents.com
Bush Herpetological	P.O. Box 539	Neodesha	KS	66757	800-451-6178		www.bushherp.com
Cajun Mice	P.O. Box 238	Centerville	LA	70522	888-919-4327	337-836-5346	www.cajunmice.com
CAP Company Surplus	767 Watson RoadMooresville	IN	46158	317-479-1738	317-831-9040		
Carolina Mouse Farm	P.O. Box 382	Salem	SC	29676	864-944-6192		www.mousefarm.com
Central Coast Reptiles	P.O. Box 5255	San Luis Obispo	CA	93401	805-546-2620		www.centralcoastreptiles.com
Colorado Rocky Mountain Rodents	1156 3950-Road	Paonia	CO	81428	800-367-3440	call first	"not yet, but coming soon"
Critters, Ltd.						845-626-5746	www.critterslimited.com
D&H Pet Farms, Inc.	3103 S. Sapp Road	Plant City	FL	33567	813-752-0257	813-759-6575	
eHerp.com	R.R. 1 Box 166	Thayer	KS	66776			www.eHerp.com
Essex Pets	Route 1, Box 171	Blum	TX	76627	800-336-6423	254-582-7306	www.essexpets.com
Hoosier Mouse Supply, Inc.	2690 Observatory Road	Martinsville	IN	46151	317-831-1219		
Kevin and Kelli Bryant	P.O. Box 4424	Evansville	IN	47724	812-867-7598	812-867-6058	www.reptilesandrodents.com
LA Mouse Farms	P.O. Box 12841	New Iberia	LA	70562	877-438-7287	337-364-9179	
LAM Distributing Co.	P.O. Box 407	Rusk	TX	75785	352-495-9024		
Lonesome Dove Rabbitry	910 Yew St.	Centralia	WA	98521	360-736-2560		
Mice on Ice (Zoological Pet Food, Inc.)	2000 SE 43rd Terrace	Gainesville	FL	32641	800-438-7287	352-377-2244	www.miceonice.com
Mice Unlimited	P.O Box 71142	Shasta Lake City	CA	96079	800-642-3496	800-642-3496	www.miceunlimited.com
Midwest Reptile and Frozen Rodents	P.O. Box 1173	Greenwood	IN	46142	317-882-8088	317-881-1856	www.midwestreptile.com
Mighty Mice	3172 N. Rainbow Blvd. 319	Las Vegas	NV	89108	708-658-0921		
Mouse House	28325 S. Cole Grade Rd. Ste. A	Valley Center	CA	92082	619-751-9929		
Mouse Trap	P.O. Box 253	Colton	OR	97017	803-824-MICE		
MZ Enterprises	10610 Emory Road	Luttrell	TN	37779	615-687-0757		
Northwest Gamebirds	228812 E. Game Farm Rd.	Kennewick	WA	99337	509-586-0150		
Oak Run Rodent Co.	P.O. Box 341	Palo Cedro	CA	96073	530-472-3294	530-472-3294	
P.S. Rodents, Mice	28120 Mary Place	Murrieta	CA	92563	909-698-6835		

Appendix 1. Partial listing of whole vertebrate prey commercial suppliers (USA).

Name	Address	City	State	Zip	Telephone	Fax	Website/email
Perfect Pets Inc.	23180 Sherwood	Belleville	MI	48111	800-366-8794	734-461-2858	FrozenRodents@aol.com
Pied Piper	Rt. 2 Box 223-AA	Speedwell	TN	37870	615-869-5524		
Quality Rodents	P.O. Box 1942	Appleton	WI	54911	920-738-7312	920-810-8920	www.qualityrodents.com
Rat Alley					800-469-5450	760-949-3372	ratalley@aol.com
Rat Ranch	2010 S. Forbes Road	Plant City	FL	33567	813-754-6258		
Rodent Empire	5050 Laguna Blvd. 112-425	Elk Grove	CA	95750	916-394-1756		
Rodents on Ice					540-989-4033		
Snake Snacks	P.O. Box 12026	New Iberia	LA	70562	877-468-7287	877-468-7287	www.snakesnacks.com
SOS Rodent Express	54 Club Road	Oley	PA	19547	610-689-4770		
Southwest Rodents	13911 S. Old Sonita Hwy	Vail	AZ	85641	520-762-5023		
Suwannee Mouse Farm	HC 1 Box 67	Old Town	FL	32680	352-542-2247		swaneemice@webtv.net
The Gourmet Rodent	6115 SW 137th Avenue	Archer	FL	32618	352-495-9024	352-495-9781	Grmtrodent@aol.com
The Mouse Factory	P.O. Box 85	Alpine	TX	79831	800-720-0076		www.themousefactory.com
Twin Oaks Livestock	1500 East Piney Road	Dickson	TN	37055	615-446-8877	615-446-8877	
Vanco	6300 Lange Road	Howell	MI	48843	517-546-8612		
Varmints	30816 144th Ave. E.	Graham	WA	98338	360-879-5580		
Wild Things	12102 N. Nebraska Ave.	Tampa	FL		813-978-8885	813-978-8885	www.globalwildthings.com
Youngs Mouseary	219 Sand Pond Road	Marlow	NH	03456	603-446-2316		

Map and State Directory can be found at: http://HerpKeepers.com/feeders/suppliers.html
For more listings see also: www.sonic.net/~melissk/preysrcs.html